Reliability Under Stress: The Impact of Localized Aging on RO-PUF Architectures in FPGAs

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Abstract

Physical Unclonable Functions (PUFs) have emerged as a promising security solution for electronic devices, but their reliability remains a critical challenge. This paper investigates the impact of localized aging on the reliability of Ring Oscillator-based PUFs (RO-PUFs) implemented on FPGAs. Using a simple and reproducible aging method, we subjected multiple FPGAs to controlled heating experiments, targeting regions with active and inactive Ring Oscillators rather than genuine RO-PUF configurations. Over 11 weeks of heating, significant and distinguishable aging effects were observed, leading to instability levels up to two times higher than normal in the RO-PUFs. These findings highlight the limitations of enrollment-time filtering countermeasures and reveal the susceptibility of RO-PUF architectures to localized aging, emphasizing the need for robust mitigation strategies.